Cross-Device Interfaces: Existing Research, Current Tools, Outlook

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ISS '16 Tutorial *(under review)*

Abstract

In this tutorial, I will describe key technical and design challenges of developing cross-device interfaces, which are not only able to adapt to a wide variety of device characteristics and user preferences, but can actually migrate a user's tasks from one device to another and even distribute the interface between multiple devices jointly used by one or more users. Starting with a review of the cross-device design concepts, authoring tools and interaction techniques presented in the ISS and larger HCI literature, I will give a comprehensive overview of the state of the art. I will then analyze the current tools for design and development of cross-device interfaces, and present one of these tools, XDBrowser, in detail. Participants will get hands-on experience with designing cross-device versions of existing interfaces using such authoring tools created for non-technical users. Finally, I will discuss open issues and provide an outlook based on the results from recent cross-device workshops I co-organized or participated in at CHI, EICS, and DIS.

Author Keywords

cross-device interface research overview; hands-on design session; open discussion and outlook

Introduction

The current proliferation of new devices ranging from smartwatches and phones, to tablets, to interactive tabletops and walls challenges designers to create flexible and adaptive interfaces. It has also prompted researchers to investigate how to best support designing for the combined use of multiple such devices. In particular, three main research streams can be identified.

First, a number of studies have been conducted on multi-device workflows [4, 13, 21, 24] and specifically cross-device web use [14, 16, 15, 27]. These studies clearly identified a need to support sequential and parallel use of multiple devices to more easily share tasks and interfaces between them.

Second, many different cross-device interaction techniques [1, 2, 23, 25, 26] have been explored. Together, they render a very rich design space for cross-device interfaces. However, at this stage, most techniques are still limited to particular sets of applications or combinations of devices, and are typically not available in the interfaces we commonly use.

A third stream of research has investigated new cross-device programming toolkits and authoring tools [3, 5, 6, 7, 8, 9, 10, 11, 18, 28]. Many of these tools are targeted at web developers, allowing them to distribute web-based interfaces between two or more devices programmatically or via direct manipulation tools.

As part of the XDBrowser project, I am investigating how existing web browsers can be extended to support parallel usage of multiple devices as motivated by previous studies. A recent paper [17] presents a first prototype that enables non-technical users to adapt existing single-device interfaces for cross-device use. The paper explores XDBrowser as an end-user customization tool allowing users to try out alternative cross-device designs during active use. The main contribution of the project so far is a study of seven common multi-device interface patterns.

It is important to have an overview of these three research streams to understand the capabilities and limitations of existing tools, and be aware of the open issues before designing yet another method or tool. This tutorial aims to provide this overview as well as a forum for discussion with designers and researchers working in the broad area of multi-device interaction. Interested participants will benefit from a thorough review of the existing solutions, including but not limited to the family of XD tools I have designed and studied over the past few years. I will also share insights from a number of workshops I co-organized or attended over the past two years at CHI, EICS and DIS. The tutorial will also include demos of the tools currently available to the community, as well as a hands-on session allowing participants to explore the cross-device design space for an interesting set of interfaces using a tool such as XDBrowser.

Tutorial Synopsis

In the following, I will outline the topics covered and hands-on activities planned for the tutorial.

This tutorial will be organized in three blocks: *(1)* the three streams of cross-device research, *(2)* the tool landscape and the design space so far, *(3)* a discussion of the open issues, and outlook.

The first block gives participants an overview of the state of the art in cross-device user interface research. Going back to the early research, I will introduce participants to the early notions of multi-device, distributed user interfaces (e.g., using a single mobile device to control

various appliances [20], redirecting input across devices [12]). Given the recent proliferation of many new forms of devices, I will then cover the more recent research efforts from the three streams mentioned earlier. In particular, I will present the most promising models, languages, frameworks and tools explored in research. The review will consider the technical aspects using Paternò and Santoro's multi-device development framework [22] as well as the design and user experience aspects based on Wljas et al.'s multi-device user experience framework [27].

This first block of the tutorial will build a comprehensive list of references useful to anyone interested in working in this field. An initial bibliography will be provided by the organizer, but participants will be asked to provide their input and help it become more complete.

The second block will be devoted to the impressive number of tools created by the community and the design space explored so far in research and practice. I will review existing tools and show interesting cross-device scenarios and applications they support according to the literature. This block will involve a practical component, where participants can try out a recent cross-device tool, XDBrowser [17], for themselves. Participants will be given examples of popular single-device web interfaces, such as GMail, YouTube and Maps, that they can then customize for cross-device use. We will then discuss the results produced by workshop participants and compare the interfaces they designed with those produced by 15 participants in a recent study presented at CHI 2016.

This second block will allow participants to get hands-on experience with recent tools such as XDBrowser to experiment with alternative cross-device designs of existing web-based interfaces while browsing them.

The third block opens the floor for discussion with participants. Participants can reflect on their experience with existing solutions, including the tools they tried in the second block. To drive the discussion, it will be moderated by the organizer and structured around three important questions: *(1)* What are promising concepts and techniques for authoring cross-device user interfaces? *(2)* What is the role of designers and developers in the process, and how does it need to change to give more power to the end-users themselves? *(3)* What may the future research agenda in cross-device user interfaces, in general and specific to ISS, look like? Here, it will be interesting to hear from participants about the research questions that they are interested in and how they would try to answer them. The organizer will then wrap up the discussion and provide an outlook based on his own research experience from the past few years and the results from four workshops recently held at CHI, EICS, and DIS.

This third block of the tutorial will foster discussion among participants. It will also be informed by the results from recent cross-device workshops held outside of, but very relevant to, ISS and the former ITS series.

Biography

Michael Nebeling is an Assistant Professor at the University of Michigan School of Information (UMSI). At UMSI, he is setting up the Information Interaction Lab, which designs and investigates more natural and powerful information interfaces. In his research, he has created and studied a family of cross-device interface tools, including XDStudio [18], a distributed user interface builder; XDKinect [19] a multi-device interaction mediation toolkit; and XDBrowser [17], which enables end-users to construct cross-device interfaces as they are browsing the web. He has recently given a number of guest lectures

and research talks on his cross-device user interface research at Carnegie Mellon University, ETH Zurich, TU Munich, University of Washington, Adobe and Google.

Acknowledgements

I would like to acknowledge the support from the Swiss National Science Foundation under mobility grants, P300P2_154571 and P300P2_164646. I also want to thank Anind Dey for his support while at CMU.

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Tutorial Organization

Participants are encouraged to bring their own devices (laptop, tablet, mobile phone) as they will be able to participate in an interactive tutorial constructing different forms of cross-device user interfaces using end-user development tools created by the organizer.

Physical requirements: There are no special requirements. Classroom setting with tables and chairs organized around a projection display is sufficient.

Requested length: I would like to structure the tutorial in three blocks of 30 minutes each (i.e., research overview, cross-device tools, discussion and outlook), with a total length of 90 minutes.